Giant Submarine Landslides on the Hawaiian Ridge: A Rebuttal[1]

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ABSTRACT: A highly precise bathymetric record shows the U.S. Navy Oceanographic Office (NAVOCEANO) chart upon which Moore's landslide hypothesis was based to be inaccurate. We find no evidence for landsliding. Three possible *in situ* origins for the seamounts in question are offered as alternatives.

TWO OPPOSING GENERAL CATEGORIES of genesis for seamounts northeast of Oahu and north of Molokai, Hawaii (Fig. 1), appear in the literature: Hamilton (1957) interpreted the seamounts as *in situ* volcanoes; Moore (1964), as giant landslides. Hamilton refers to "slopes, symmetrical profiles, oval shapes in plan, and . . . the volcanic material cored from their slopes or the adjacent sea floor." Moore interpreted NAVOCEANO preliminary chart BC1604N and found tilted flat upper surfaces of elongate blocky seamounts and rather constant distances between adjacent crests and adjacent troughs. Langford (1969) reported morphologic details of the largest of the seamounts (Fig. 2) and favored a volcanic origin for it.

So that we might evaluate[3] the accuracy of NAVOCEANO BC and LC charts and reconsider the problem of the seamounts' origin, we decided to obtain a highly precise bathymetric record along part of Moore's A–A′ profile (close to but not the same as Hamilton's A–A′ profile which is not shown here). A sediment sample from the top of Tuscaloosa Seamount was studied incidentally.

R.V. *Mahi* was guided by radio instructions based on 3-minute Hawaii Army National Guard radar fixes. A 3.5 kHz 2,000-watt transducer with a 0.2 to 0.5 msec variable pulse length and 30° cone provided a continuous bathymetric record which was read at each fix, maxima, and minima. More than 90 percent of the fixes plotted within 200 m of the smooth-plotted track. The ship crossed line A–A′ several times but was never farther from it than 800 m. A table of navigational details and bathymetric data is available on request.

Geophysical data in support of *in situ* volcanism include a single dipole defined by a magnetic profile of Tuscaloosa Seamount (Stearns, 1966). Magnetically anomalous bodies in the area of Fig. 1 number seven; four are transected by Moore's A–A′, and the other three lie close to Molokai (Malahoff and Woollard, 1968). Gravity highs trend parallel to A–A′ northeastward from Ulupau Head, Oahu (Strange, Machesky, and Woollard, 1965).

Three possible *in situ* origins for the seamounts are offered here; all such hypotheses will be highly speculative until more detailed bathymetric and subbottom data are available. (1) If, as its guyotlike profile may suggest, Tuscaloosa Seamount has been wave-cut, the 2,765 meters of subsidence would agree well with the 9,000 feet of subsidence proposed for the Hawaiian Ridge by Stearns (1966). This agreement may imply, but does not prove, that the seamounts antedate the Ridge. Further work is needed on the question. (2) If Oahu and Molokai have undergone subaerial erosion, partial submergence, and continuing submarine differential erosion (Shepard and Dill, 1966), the seamounts may have been carved from a shield whose original diameter at its base (measured normal to the Ridge) was comparable to the diameter of the present-day Hawaii Island

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[1] Hawaii Institute of Geophysics Contribution no. 445. Manuscript submitted 20 September 1971.

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[3] We realize that most people who study the ocean bottom are well aware of the dangers of trying to do much geology with available BC charts, and we offer precious little new data here with which to modify existing charts. Nonetheless, Moore's conclusions stand virtually unchallenged in the literature; this is the justification for this humble contribution.

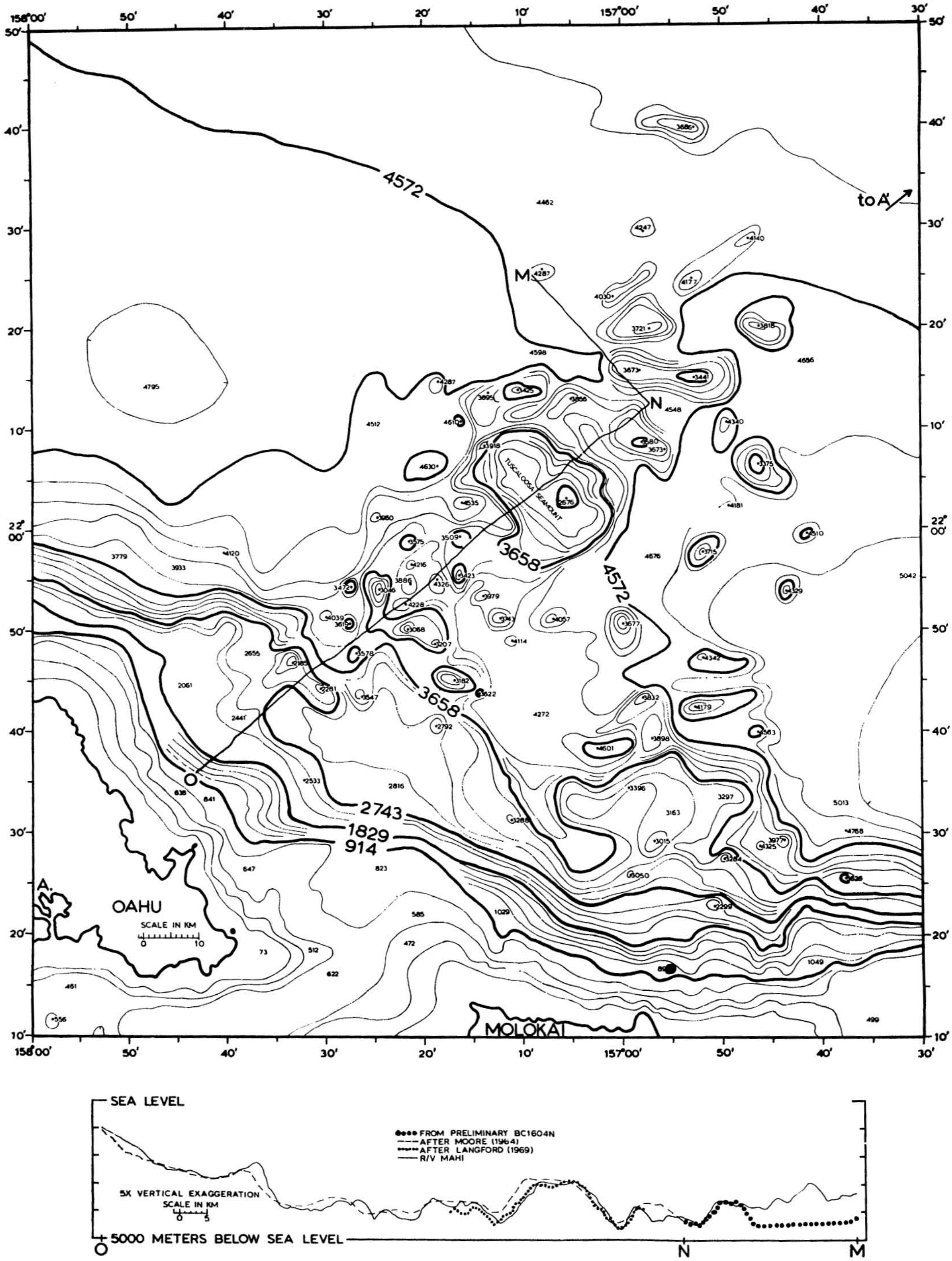

FIG. 1. R.V. *Mahi*'s track M–N–O on plan view adapted without changing contours from chart 1604-LC; all values converted from fathoms to meters. Profiles from different sources are compared to M–N and N–O. All depths from Langford (1969) and R.V. *Mahi* are corrected for sound velocity (Belshé, 1967). Since preliminary BC1604N lacked depth values for closed contours, these being added during production of chart 1604-LC without significant changes being introduced along R.V. *Mahi*'s N–O track; we have used the latter chart. Contours omitted by NAVOCEANO because of drafting difficulties have not been added here.

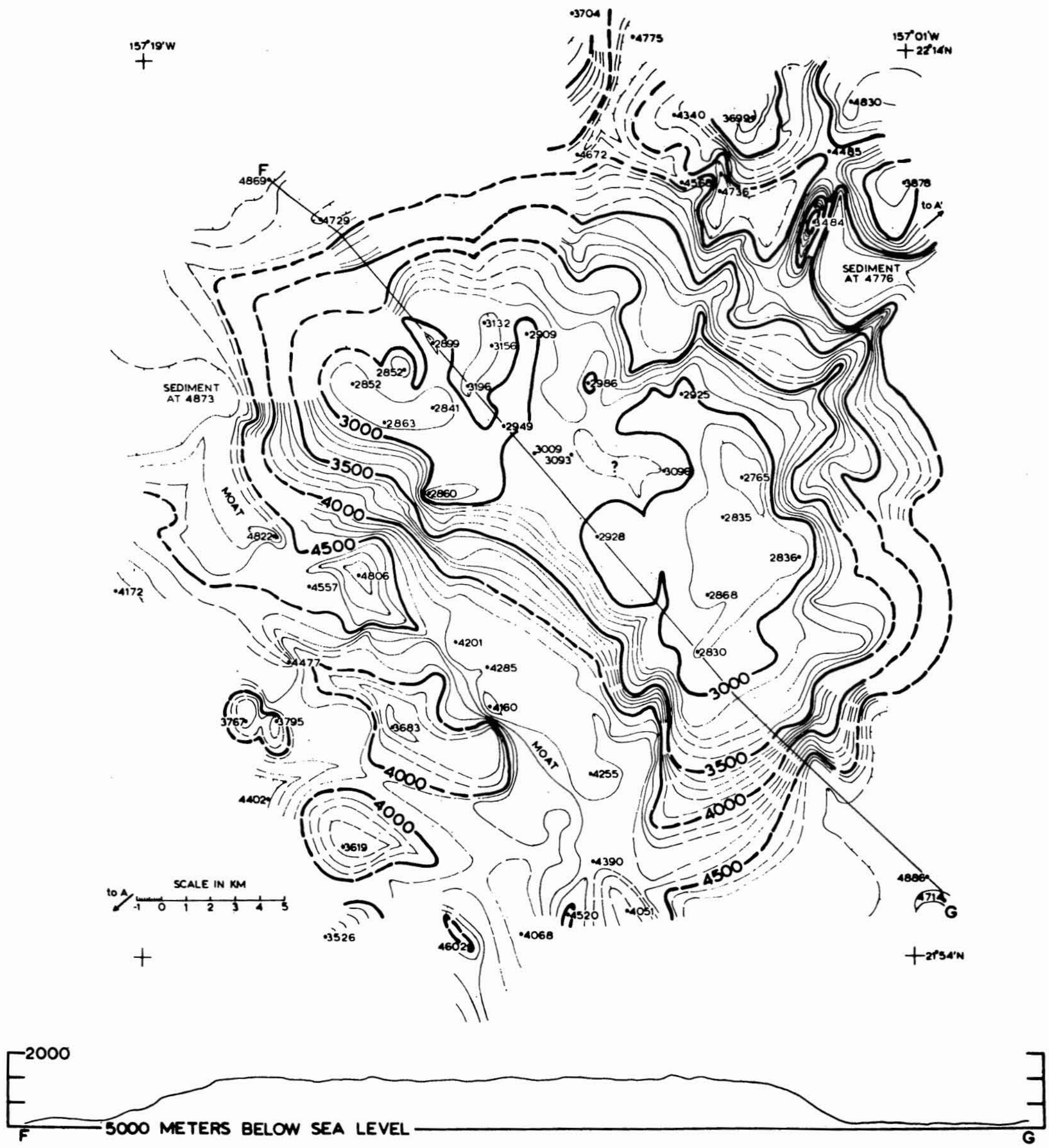

FIG. 2. Surface morphology of Tuscaloosa Seamount with unexaggerated profile F–G (after Langford, 1969).

shield. It seems improbable that the time available would allow predominantly submarine erosion to create such relief, so we tentatively reject the hypothesis while suggesting need for more definitive work. (3) If predominantly submarine secondary eruptions have formed the seamounts rather recently, a combination of submarine erosion and sediment ponding would probably have altered the original topography to some as yet poorly defined extent. We favor the latter hypothesis and develop it below.

RESULTS AND DISCUSSION

The Moore and NAVOCEANO profiles are seen (Fig. 1) to correlate poorly with those of

Langford and this work. The R.V. *Mahi*'s profile N–O looks more like Hamilton's than Moore's A–A′ profile. Most depths found by R.V. *Mahi* are not shown within the limits of a 30° cone along M–N–O on the NAVOCEANO charts.

Figure 2 shows both NAVOCEANO's and Hamilton's contours of the region to be oversimplified, but Hamilton's profile (see the reference) has more the character of the R.V. *Mahi*'s profile than does Moore's. Moreover, neither the blockiness, flat upper surfaces (the closest approach to one is profile F–G of Fig. 2), tilting, constant distances between adjacent troughs or adjacent crests pointed out by Moore, nor any other morphologic evidence suggestive of sliding has been found by Hamilton, Langford, or us. Furthermore, since the depths along A–A′ on NAVOCEANO 1604 charts are inaccurate, the landsliding hypothesis is untenable.

Sediments from the top of Tuscaloosa Seamount were studied to see if they bear on the genesis question. Volcanic grains of less than 1/8 mm diameter and some foraminifera were found. Euhedral to anhedral olivine (Fo_{75}), labradorite, and pigeonite grains are associated with microlitic, nonvesicular basalt and occasional vesicular(?) palagonite(?) fragments in a sugary, microbrecciated matrix which may contain clays and zeolites. Botryoidal coatings and dendritic penetrations of wad are present. Vesicles are generally absent. Volcanic parts of the sample seem consistent with either category of genesis hypothesis; the presence of recent deep-water foraminifera do not bear on that question; so the sediments studied do not bear on this work.

A genetic connection among an abrupt change in Trough depth, Honolulu volcanic rocks, and the seamounts is suggested by the 700-plus meter increase observed in Hawaiian Trough depth from northwest to southeast across the seamounts, by the proximity of Tuscaloosa Seamount to extensions of Honolulu Volcanic Series Kaau and Koko rifts (Winchell, 1947), and by the above-mentioned geophysical data. Upon cessation of main shield-building along the older Hawaiian Ridge, an upward rebound of the Trough northwest of the seamounts from a former maximum depth may have been caused by: erosion of the older islands, subsidence and reincorporation into the mantle of the base of the older Ridge, a lack of removal of material from below, lateral flow toward the Trough of mantle material displaced by the sinking Ridge, and perhaps mantle phase changes on withdrawal of heat (Macdonald and Abbott, 1970). This rebound and the continuing subsidence of the Trough southeast of the seamounts, due to active shield-building along the nearby Ridge, may have then produced vertical or normal faults. Magma from sources at great depths (Honolulu Series' eruptions probably come from depths in excess of 100 km) could have thereby travelled to produce the seamounts in question. Petrologic affinities of the seamounts, as yet unclear, may bear heavily on the future of this tentatively favored hypothesis.

It has been suggested that some guyots may be features solely of submarine volcanism (Bonatti, 1970; Simkin, 1970); Tuscaloosa Seamount may be one such or may be wave-cut. Future petrologic and morphologic studies should aim at solving this question and thereby facilitate choices among the possible genetic hypotheses.

CONCLUSIONS

NAVOCEANO 1604 charts, the best available for deep Hawaiian waters, are not definitive surveys of the region considered. Moore's evidence for landsliding is not substantiated. We agree with Hamilton that the seamounts are *in situ* volcanoes (possibly modified by subaerial and submarine erosion) that may possibly have moved vertically, but not horizontally, with respect to the crust beneath them.

ACKNOWLEDGMENTS

The following people and institutions are thanked for their assistance: Dr. James E. Andrews; Dr. John C. Belshé; Arthur G. Cropper; William A. Foster, Jr.; Lt. Cdr. L. Thomas Gray, Jr.; James F. Hamilton; Hawaii Army National Guard; Capt. Noboru Kon; Dr. Gordon A. Macdonald; Dr. Alexander Malahoff; Mrs. Ethel McAfee; Dr. Ralph Moberly, Jr.; NAVOCEANO; Dr. Johanna M. Resig; Lt.

Wayne B. Stroupe; and Dr. George P. Woollard.

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